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U.S. Timber Resources

1970

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Renewable resources evaluation research, formerly called the Forest Survey, is a nationwide project of the Forest Service authorized by the McSweeney-McNary Forest Research Act of 1928 and subsequent amendments, and by the Renewable Resources Planning Act of 1974 (Public Law 93-378). Resource surveys are conducted throughout the 50 States by Forest Service experiment stations. The Pacific Northwest Forest and Range Experiment Station, headquartered at Portland, Oregon, is responsible for surveys in the States of Alaska, California, Hawaii, Oregon, and Washington.

The resource inventory reported in this Resource Bulletin was a cooperative effort of these agencies:

- Division of Forestry, Hawaii Department of Land and Natural Resources
- Renewable Resources Evaluation Research Unit, Pacific Northwest Forest and Range Experiment Station
- Institute of Pacific Islands Forestry, Pacific Southwest Forest and Range Experiment Station

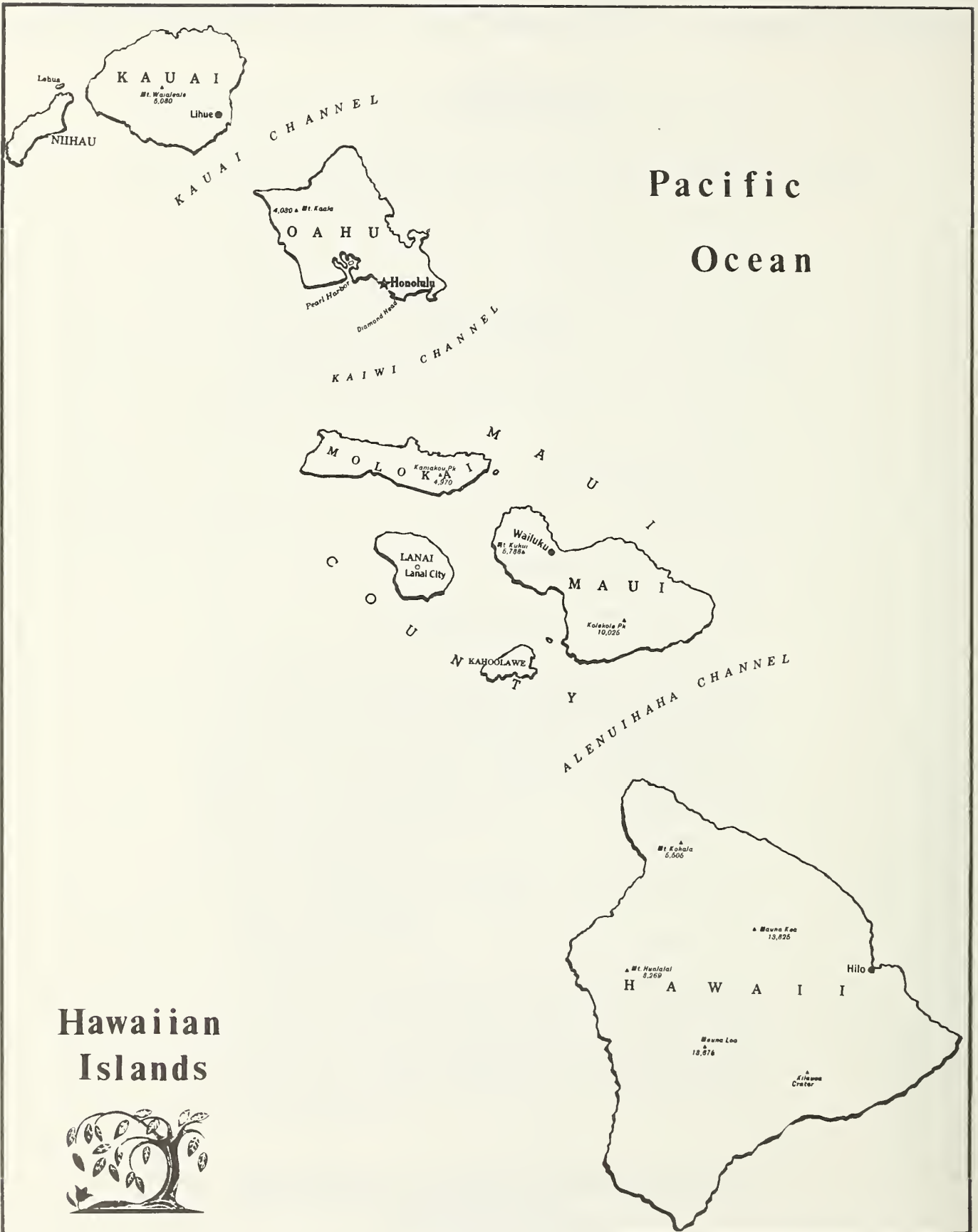
Many members of the cooperating agencies participated in various phases of the survey work, notably *Wesley H.C. Wong, Jr.*, forester, Hawaii Division of Forestry, who contributed materially to the planning of the survey and supervised all data collection work; *Charles L. Bolsinger*, forest survey specialist, Pacific Northwest Station, who helped organize the data collection procedures; and *Herbert L. Wick*, formerly research forester at the Pacific Southwest Station, who helped plan the survey.

Hawaii's Timber Resources 1970

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Facts about Hawaii's forest resources are greatly needed. Only on a factual basis can forest managers plan effectively for management, evaluate the contribution of diverse forest resources to the local, state, and national economies, and appraise the prospects for sustained local forest products industries.

The first inventory of Hawaii's forest resources was conducted in 1958-61 as a cooperative undertaking by the Forestry Division of the Hawaii Department of Land and Natural Resources and the Pacific Southwest Forest and Range Experiment Station, of the Forest Service, U.S. Department of Agriculture. The inventory was part of the nationwide forest survey authorized by Section 9 of the McSweeney-McNary Forest Research Act of 1928. The results were published in the report "Forest Resources of Hawaii—1961" (Nelson and Wheeler 1963). No information on rates of growth of the native forests was obtained from the initial survey because annual growth rings are not identifiable in the native trees. There was also no satisfactory way of dating mortality. A second inventory about 10 years later was planned to provide a new assessment of the resource and estimates of growth and mortality.

Over the period 1965-67, the two cooperating agencies made detailed inventories of the planted forests and published the results for each island (as cited below under "Forest Plantations"). Most information concerning planted forests that is presented in this report is from these earlier inventories.

As planned, a reinventory was begun in 1969, this time a cooperative effort of the Hawaii Division of Forestry; the Forest Survey project of the Pacific Northwest Forest and Range Experiment Station; and the Institute of Pacific Islands Forestry, of the Pacific Southwest Forest and Range Experiment Station. Field work was carried out between 1969 and 1971. This report presents the results of the resurvey of Hawaii's forests.

A brief description of the inventory procedures is given in the section "Survey Methods." Details are available from any of the principal cooperators. Differences in inventory techniques and standards in this second survey prevent some direct comparisons with data from the initial survey. Therefore, those interested in comparing information in the two reports should pay particular attention to the section "Definitions of Terms."

The spelling of Hawaiian plant names in this Bulletin follows *A Provisional Check List of Some Common Native and Introduced Forest Plants in Hawaii* (Bryan and Walker 1962) with the addition of the macron in those names where it is used in Hawaiian spelling. The macron is a symbol of vowel length and of stress that does not conform to the predictable pattern. For further information, see the *Hawaiian Dictionary: Hawaiian-English, English-Hawaiian* (Pukui and Elbert 1971).

TIMBER RESOURCE HIGHLIGHTS

The findings of the resource inventory of Hawaii are presented in 21 tables. The following discussion selects highlights from these statistics and provides perspective by indicating what they mean in proportional terms.

Forests cover 1,986,000 acres—almost one-half of Hawaii's land surface of 4,110,000 acres (*table 1*). Most of the forests—1,940,000 acres are native and naturalized forest types; about 46,000 acres are planted forest types. Slightly less than one-half (902,000

acres) of the native and naturalized forest is on commercial forest land—land that is capable of growing timber crops of commercial quality, and not reserved for uses which restrict timber production. A significant portion of the land area of each of the five main islands is commercial forest land.

About 52 percent (1,038,000 acres) of the total forest land area is classified as noncommercial—incapable of producing commercial wood crops. Of this, productive reserved forest lands total 114,000

acres, mostly in Hawaii Volcanoes National Park on the island of Hawaii, and Haleakala National Park on the island of Maui. Unproductive forest land, 924,000 acres of it, makes up the remainder of the noncommercial classification.

Native and Naturalized Forest

Only 26 percent of the commercial forest land is currently classified as productive for native timber.

Of the 902,000 acres of commercial forest land having native or naturalized forest types, about 61 percent are on the island of Hawaii (*table 2*). However, only 238,000 acres, or 26 percent, of the native and naturalized forests on commercial forest land are classified as commercial forest types (*table 3*). These commercial native stands occur only on the island of Hawaii. Noncommercial forest types occupy the remaining 664,000 acres of commercial forest land. Thus, although these areas have soils and climate suited to growing timber crops, they are now occupied by forest types, mostly native, which do not have timber potential. The noncommercial 'ohi'a-koa type is the most extensive, occurring on 383,000 acres, or 58 percent of the area. Nearly one-half, or 313,000 acres, of noncommercial forest types on commercial forest land are on the island of Hawaii.

Of the 238,000 acres of commercial forest types, about 188,000 acres are occupied by forests classified as sawtimber stands (*table 4*). On the balance, over 50,000 acres, there are forests classified as poletimber, sapling, and seedling stands.

In the total 238,000 acres of commercial forest types on commercial forest land, there are about 88,000 acres with less than 80 square feet of basal area per acre. There are only 58,000 acres with basal area of 140 or more square feet per acre (*table 5*).

Nearly three-fourths of the commercial forest land lies below 4000 feet in elevation. One-third is in rainfall belts of more than 125 inches per year (*table 6*).

More than one-half of the commercial forest land is in private ownership.

Statewide, the commercial forest land is fairly evenly divided between public holdings, 47 percent, and private owners, 53 percent (*table 2*). Public and private ownerships are also nearly equal on the island of Hawaii. For the other islands, as a whole, public holdings amount to only 40 percent of the total.

The State of Hawaii owns 411,000 acres, or 97 percent, of the commercial forest lands that are in public ownership. Of the private holdings, corporate ownership totals 283,000 acres, compared to 195,000 acres for individual owners.

Over one-half of the commercial forest land is inside the forest reserves.

For the State as a whole, the commercial forest land is about evenly distributed inside and outside the forest reserves—52 percent inside and 48 percent outside (*tables 2, 3*). The proportions vary considerably by ownership classes, however, two-thirds of the publicly owned commercial forest lands are inside forest reserves. In contrast, only 38 percent of the private lands are inside the reserves.

'Ohi'a is the dominant forest type.

In the 238,000 acres of commercial native and naturalized forest types, 'ohi'a-lehua (*Metrosideros collina*) is the predominant species on 174,000 acres, or 73 percent of the area; koa (*Acacia koa*) predominates on 8 percent; and a combination of 'ohi'a and koa, with neither predominating, on 18 percent (*table 3*). Monkey-pod (*Pithecellobium saman*) is predominant on about 1 percent of the area of commercial forest type.

The 'ohi'a and 'ohi'a-koa types are fairly evenly distributed between the State and private holdings and inside and outside the forest reserves. The koa type, on the other hand, is heavily concentrated in the private holdings outside the forest reserves.

On the 924,000 acres of unproductive noncommercial forest lands—that is, lands not capable of producing commercial crops of timber—shrub types predominate, occupying one-half of the area (*table 7*). 'Ohi'a-koa and kiawe (*Prosopis pallida*) types also occupy extensive acreages.

Three-fourths of current timber volume is 'ohi'a.

Commercial native and naturalized forest types on commercial forest land, all on the island of Hawaii, hold a total volume of 140.9 million cubic feet of wood in trees of commercial species and quality—growing stock trees—5.0 inches and larger in diameter breast height (*table 8*). This amounts to 760.7 million board feet of sawtimber in trees 11.0 inches in diameter and larger (*table 9*). The average sawtimber volume per acre in the native and naturalized commercial forest types is 3200 board feet.

Three-fourths of the sawtimber volume is 'ohi'a, and slightly more than one-half is in public ownership (*table 10*). Private owners hold 72 percent of the 187.3 million board feet of koa.

Overall, the timber volume is relatively evenly distributed inside and outside the forest reserves, 53 and 47 percent respectively (*table 11*). However, timber ownership is disproportionate inside and outside the reserves. Public ownership accounts for 68 percent of the volume inside the reserves, but only 28 percent of the volume outside the reserves. The 'ohi'a timber

volume is heavily concentrated in the 'ohi'a forest type; koa timber volume is well represented in all three commercial forest types—'ohi'a, koa, and 'ohi'a-koa (table 12).

About 46 percent of the growing stock volume, 65 million cubic feet, is in trees in the three diameter classes, ranging from 15 to 28 inches d.b.h. In sawtimber there is a total of 461 million board feet, 61 percent, in trees in these three classes. Koa sawtimber volume is heavily concentrated—93 percent—in trees 19 inches d.b.h. and larger (table 13).

Only 7 percent of the sawtimber volume is in grade 1 factory logs, an indication of the relatively low quality of native timber (table 14).

Some 2.4 million craftwood bolts, totaling 11.7 million cubic feet, are estimated to be in the commercial forest types on the island of Hawaii (table 15). This material, practically all koa, is in addition to the estimated sawtimber volume.

The inventory also found 46.2 million cubic feet of treefern in the commercial forest types on the island of Hawaii (table 16). Sixty-two percent of this volume is Hapu'u-'i'i (*Cibotium menziesii*) and the rest is Hapu'u-pulu (*Cibotium splendens*). About one-fourth (24 percent) is in treeferns greater than 15 inches in diameter, and having greater than 11 feet of merchantable length (table 17).

Mortality exceeds growth of koa.

Estimates of annual growth and mortality were obtained by remeasuring in 1969-70 the trees tallied on sample plots in the 1959-60 inventory on the island of Hawaii. Total net annual growth of 'ohi'a was found to be 6.4 million board feet in sawtimber trees and 1.6 million cubic feet in growing stock trees (table 18). However, net annual growth of koa was found to be a negative 4.5 million board feet of sawtimber and a negative 0.6 million cubic feet of growing stock. Mortality of koa sawtimber and growing stock exceeded growth, whereas growth of 'ohi'a sawtimber and growing stock exceeded mortality (table 19).

Additional timber losses due to epidemic forest decline have been estimated.

The estimates of the timber volumes and mortality

on the island of Hawaii were developed prior to the study of the epidemic 'ohi'a forest decline (Pettyes and others 1975). Because most of the field plot data were collected in 1969, the estimates can be expected to reflect to some degree the timber losses due to the epidemic decline through 1969. They do not reflect losses since that time, however. The rate of forest loss to severe decline has been estimated to be about 6500 acres per year since 1965 (Pettyes and others 1975). Based on average sawtimber volume per acre, this implies a timber loss rate of about 21 million board feet per year.

The data show that the volumes of both koa and 'ohi'a timber are decreasing as a result of mortality greatly exceeding natural growth.

Forest Plantations

There are 46,000 acres of planted forests on commercial forest land in Hawaii (table 20) (Honda and others 1967; Nelson and others 1966; Nelson and others 1968; Wong and others 1967; Wong and others 1968; Wong and others 1969). Hawaii and Maui islands have 62 percent of the planted forests. Approximately 34,000 acres of these plantations are commercial forest types. The remaining 13,000 acres are non-commercial forest types.

One-half of the area of planted commercial forests is made up of eucalypts. About 26 percent of the planted commercial forests are other hardwood species, including Australian redcedar, (*Toona australis*), nepal alder (*Alnus nepalensis*), and albizzia (*Albizia moluccana*). Conifer species make up about 14 percent of the planted commercial forests.

The planted commercial forests contain some 69 million cubic feet of wood in trees 5.0 inches in diameter and larger. In sawtimber trees, there are 296 million board feet, 88 percent of which is in eucalypts (table 21).

The island of Hawaii alone has 40 percent of the total plantation sawtimber volume; Maui island has 33 percent.

SURVEY METHODS

Data Gathering

Aerial photointerpretation sampling techniques were used to determine area statistics for land use, ownership, and forest type. A total of 15,199 photo sample plots were interpreted and 523 of these were ground checked. The ground checks provided correc-

tion factors for interpretation errors and changes occurring after the time of the photography. The area estimated for a given category (land use class, forest type, commercial forest land, etc.) is proportional to the number of photo sample plots in that category.

The volume of timber was measured on 38 of the plots, all in native and naturalized commercial forest

types on the island of Hawaii, as no native or naturalized forest types were classified as commercial forest types on the other islands. Each ground plot consisted of 10 subplots in which trees were measured according to the variable radius plot system. Twenty-eight of the plots measured had been measured in the first survey, and thus provided information on growth and mortality.

Plantation stands were not reinventoried. The results of the plantation inventories that had been made for each island in 1964-67 were adjusted to include the acreage of the new plantings, and an estimate of the growing stock volume in poletimber-size plantations was made. The adjusted area and volume information is included in selected tables in this report.

Accuracy of Current Inventory Data

Sampling errors have been computed for the estimates of land areas and timber volumes.

As area or volume data are subdivided by forest type, species, island, or other breakdown, the sampling error increases. The order of the increase is

suggested in the following tabulation. These sampling errors mean that at odds of two out of three (68 percent probability) the true inventory values will lie within the ranges shown.

	Data Value	Sampling error (percent)
Data item:		
Forest area (thousand acres)	500	3.8
	100	8.5
	10	26.7
Timber, cubic volume (million cubic feet)	100	20.0
	50	28.8
Timber, board-foot volume (million board feet)	500	22.6
	200	35.0

In addition to measurable sampling errors, there may be errors in judgment, measurement, and compilation, for which the magnitude cannot be determined. The likelihood of such errors was minimized, however, through training and supervision of personnel, field checking of data, and complete editing and machine verification of results of the compilation.

TABLES

Table 1--Area by land class, State of Hawaii, 1970

Land class	State total	Hawaii	Kahoolawe	Kauai	Lanai	Maui	Molokai	Niihau	Oahu
Thousand acres									
Forest land:									
Commercial:									
Plantations	46.1	18.1	--	5.6	1.0	10.6	2.6	--	8.2
Native and naturalized forests	901.7	551.3	--	140.3	3.5	56.9	31.4	--	118.3
Total	947.8	569.4	--	145.9	4.5	67.5	34.0	--	126.5
Noncommercial:									
Productive reserved	114.4	71.5	--	2.3	--	30.3	.3	--	10.0
Unproductive	924.2	511.6	15.8	71.7	39.4	142.0	43.8	31.1	68.8
Total	1,038.6	583.1	15.8	74.0	39.4	172.3	44.1	31.1	78.8
Total forest land	1,986.4	1,152.5	15.8	219.9	43.9	239.8	78.1	31.1	205.3
Nonforest land ¹	2,123.4	1,431.2	13.0	131.3	45.4	226.2	88.9	13.4	174.0
All land classes	4,109.8	2,583.7	28.8	351.2	89.3	466.0	167.0	44.5	379.3

¹Includes areas of water less than 40 acres in size, defined by the Bureau of Census as land.

Table 2--Area of commercial forest land in native and naturalized forest, by ownership classes, and forest reserve status, island of Hawaii, and all other islands, Hawaii, 1970

Ownership classes	State			Island of Hawaii			All other islands		
	Total	Inside reserve	Outside reserve	Total	Inside reserve	Outside reserve	Total	Inside reserve	Outside reserve
Thousand acres									
Public:									
State:									
Hawaiian homes	34.0	--	34.0	6.3	--	6.3	27.7	--	27.7
Other	377.4	272.6	104.8	278.0	189.3	88.7	99.4	83.3	16.1
Miscellaneous Federal	11.8	11.8	--	--	--	--	11.8	11.8	--
Total public	423.2	284.4	138.8	284.3	189.3	95.0	138.9	95.1	43.8
Private:									
Corporate	283.4	134.5	148.9	140.5	36.8	103.7	142.9	97.7	45.2
Individual	195.1	48.1	147.0	126.5	12.2	114.3	68.6	35.9	32.7
Total private	478.5	182.6	295.9	267.0	49.0	218.0	211.5	133.6	77.9
All classes	901.7	467.0	434.7	551.3	238.3	313.0	350.4	228.7	121.7

Table 3--Area of commercial forest land in native and naturalized forests by forest type, forest reserve status, and owner group, Hawaii, 1970

Forest types	State totals	State						Island of Hawaii						All other islands					
		Forest reserve			Outside reserve			Forest reserve			Outside reserve			Forest reserve			Outside reserve		
		Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private
Thousand acres																			
Commercial:																			
'Ōhi'a	174.1	91.6	67.2	24.4	82.5	28.1	54.5	91.6	67.2	24.4	82.5	28.1	54.4	--	--	--	--	--	--
Koa	18.6	--	--	--	18.6	2.7	15.9	--	--	--	18.6	2.7	15.9	--	--	--	--	--	--
'Ōhi'a-Koa	43.2	23.1	17.0	6.1	20.1	6.1	14.0	23.1	17.0	6.1	20.1	6.1	14.0	--	--	--	--	--	--
Monkey-pod	2.2	--	--	--	2.2	--	2.2	--	--	--	2.2	--	2.2	--	--	--	--	--	--
Total	238.1	114.7	84.2	30.5	123.4	36.9	86.5	114.7	84.2	30.5	123.4	36.9	86.5	--	--	--	--	--	--
Noncommercial:																			
Kukui	6.3	6.3	6.3	--	--	--	--	6.3	6.3	--	--	--	--	--	--	--	--	--	--
'Ōhi'a-Koa	383.0	249.0	138.4	110.6	134.0	46.9	87.1	117.3	98.8	18.5	129.8	42.7	87.1	131.7	39.6	92.1	4.2	4.2	--
Other noncommercial tree types	13.0	.6	--	.6	12.4	12.4	--	--	--	--	--	--	--	.6	--	.6	12.4	12.4	--
Shrub types	261.3	96.4	55.5	40.9	164.9	42.7	122.2	--	--	--	59.8	15.4	44.4	96.4	55.5	40.9	105.1	27.3	77.8
Total	663.6	352.3	200.2	152.1	311.3	102.0	209.3	123.6	105.1	18.5	189.6	58.1	131.5	228.7	95.1	133.6	121.7	43.9	77.8
All forest types	901.7	467.0	284.4	182.6	434.7	138.9	295.8	238.3	189.3	49.0	313.0	95.0	218.1	228.7	95.1	133.6	121.7	43.9	77.8

Table 4--Area of commercial forest land in native and naturalized forests classified as commercial forest types of stand volume and stand size classes, island of Hawaii, 1970

Stand volumes	All classes	Sawtimber stands	Poletimber, sapling, and seedling stands
	Thousand acres		
Cubic feet per acre: ¹			
Less than 1,000	120.1	77.2	42.9
1,000-1,999	85.2	83.8	1.4
2,000-2,999	19.2	13.1	6.1
3,000 or more	13.6	13.6	--
Total	238.1	187.7	50.4
Board feet per acre: ²			
Less than 1,500	69.7	31.7	38.0
1,500-4,999	122.5	110.1	12.4
5,000-9,999	33.7	33.7	--
10,000 or more	12.2	12.2	--
Total	238.1	187.7	50.4

¹Net cubic volume, trees 5.0 inches d.b.h. and larger to 4.0 inches top d.o.b.

²Net board foot volume, International 1/4-inch rule, trees 11.0 inches d.b.h. and larger to 9.0 inches top d.o.b.

Table 5--Area of commercial forest land in native and naturalized forests classified as commercial forest types by basal area stocking classes and stand size classes, island of Hawaii, 1970

Basal area stocking class (square feet basal area ¹) per acre	All classes	Sawtimber stands	Poletimber, sapling, and seedling stands
	Thousand acres		
Less than 20	6.7	6.7	--
20-39	13.6	7.5	6.1
40-59	19.2	7.0	12.2
60-79	49.0	36.8	12.2
80-99	20.6	20.6	--
100-119	32.6	24.9	7.7
120-139	37.9	31.8	6.1
140 and over	58.5	52.4	6.1
Total	238.1	187.7	50.4

¹All live trees 5.0 inches d.b.h. and larger.

Table 6--Area of commercial forest land in native and naturalized forests by elevation and precipitation, Hawaii, 1970

Average annual precipitation (inches)	Elevation (feet)				
	Total	00-2000	2000-4000	4000-6000	6000+
	<u>Thousand acres</u>				
30	41.2	19.7	16.1	4.4	1.0
40	71.4	32.5	16.9	17.2	4.8
50	157.2	70.5	45.8	35.3	5.6
75	108.0	32.5	41.4	31.0	3.1
100	217.7	94.0	64.3	50.4	9.0
150	152.6	53.7	54.6	43.6	.7
200	87.6	28.1	46.0	13.3	.2
250+	66.0	8.7	40.4	6.0	10.9
Total	901.7	339.7	325.5	201.2	35.3

Table 8--Volume of timber on commercial forest land in native and naturalized forests classified as commercial forest types, by class of timber, island of Hawaii, 1970

Class of timber	Volume
	<u>Thousand cubic feet</u>
Sawtimber trees:	
Saw log portion	106,495
Upper-stem portion	3,957
Total	110,452
Poletimber trees	30,400
All growing stock trees	140,852
Sound cull	19,335
Rotten cull	12,510
Salvable dead sawtimber trees	11,331
Total all timber	184,028

Table 7--Area of unproductive noncommercial forest land in native and naturalized forests by noncommercial forest type and forest reserve status, Hawaii, 1970

Noncommercial forest types	Total area	Inside forest reserve	Outside forest reserve
----- Thousand acres -----			
Island of Hawaii			
Kukui	12.3	11.3	1.0
'Ōhi'a-Koa	181.5	31.6	149.9
Kiawe	33.1	--	33.1
Shrub types	284.7	3.1	281.6
Total	511.6	46.0	465.6
Island of Kahoolawe			
Kiawe	15.8	--	15.8
Total	15.8	--	15.8
Island of Kauai			
'Ōhi'a-Koa	28.6	.6	28.0
Shrub types	43.1	.6	42.5
Total	71.7	1.2	70.5
Island of Lanai			
Kiawe	39.4	--	39.4
Total	39.4	--	39.4
Island of Maui			
Kukui	19.1	.2	18.9
'Ōhi'a-Koa	15.7	15.7	--
Kiawe	39.6	--	39.6
Shrub types	67.6	6.9	60.7
Total	142.0	22.8	119.2

Table 7--Area of unproductive noncommercial forest land in native and naturalized forests by noncommercial forest type and forest reserve status, Hawaii, 1970, Continued

Noncommercial forest types	Total area	Inside forest reserve	Outside forest reserve
----- Thousand acres -----			
Island of Molokai			
'Ōhi'a-Koa	5.2	.8	4.4
Kiawe	32.3	--	32.3
Shrub types	6.3	--	6.3
Total	43.8	.8	43.0
Island of Niihau			
Kiawe	10.4	--	10.4
Shrub types	20.7	--	20.7
Total	31.1	--	31.1
Island of Oahu			
Kukui	.2	.2	--
'Ōhi'a-Koa	1.1	1.1	--
Kiawe	27.6	--	27.6
Shrub types	39.9	.9	39.0
Total	68.8	2.2	66.6
State of Hawaii			
Kukui	31.6	11.7	19.9
'Ōhi'a-Koa	232.1	49.8	182.3
Kiawe	198.2	--	198.2
Shrub types	462.3	11.5	450.8
Total	924.2	73.0	851.2

Table 9--Volume of growing stock and sawtimber on commercial forest land in native and naturalized forests classified as commercial forest types by stand-size class, island of Hawaii, 1970

Stand-size class	Growing stock		Sawtimber ¹	
	Average volume per acre	Total	Average volume per acre	Total
	<u>Cubic feet</u>	<u>Thousand cubic feet</u>	<u>Board feet</u>	<u>Thousand board feet</u>
Sawtimber stands	632	118,693	3,810	715,185
Poletimber, sapling and seedling stands	440	22,159	903	45,534
Total	592	140,852	3,195	760,719

¹International 1/4-inch rule.

Table 10--Volume of growing stock and sawtimber on commercial forest land in native and naturalized forests classified as commercial forest types by species and owner group, island of Hawaii, 1970

Species	All owners	Public	Private
	Growing stock		
	<u>Thousand cubic feet</u>		
'Ōhi'a	115,331	62,090	53,241
Koa	25,218	6,764	18,454
Monkey-pod	303	--	303
All species	140,852	68,854	71,998
	Sawtimber (International 1/4-inch rule)		
	<u>Thousand board feet</u>		
'Ōh'ia	571,509	321,193	250,316
Koa	187,265	51,642	135,623
Monkey-pod	1,945	--	1,945
All species	760,719	372,835	387,884

Table 11--Volume of growing stock and sawtimber on commercial forest land in native and naturalized forests classified as commercial forest types by owner group and by forest reserve status, island of Hawaii, 1970

Owner group	Total	Inside reserve	Outside reserve
Growing stock			
----- Thousand cubic feet -----			
Public	68,854	50,442	18,412
Private	71,998	23,714	48,284
All owners	140,852	74,156	66,696
Sawtimber (International 1/4-inch rule)			
----- Thousand board feet -----			
Public	372,835	267,815	105,020
Private	387,884	126,976	260,908
All owners	760,719	394,791	365,928

Table 12--Volume of growing stock and sawtimber on commercial forest land in native and naturalized forests classified as commercial forest types by species and forest type, island of Hawaii, 1970

Species	Forest type				
	All types	'Ōhi'a	Koa	'Ōhi'a-Koa	Monkey-pod
Growing stock					
----- Thousand cubic feet -----					
'Ōhi'a	115,331	104,322	896	10,113	--
Koa	25,218	6,019	9,811	9,388	--
Monkey-pod	303	--	--	--	303
All species	140,852	110,341	10,707	19,501	303
Sawtimber (International 1/4-inch rule)					
----- Thousand board feet -----					
'Ōhi'a	571,509	529,284	5,234	36,991	--
Koa	187,265	40,263	74,267	72,735	--
Monkey-pod	1,945	--	--	--	1,945
All species	760,719	569,547	79,501	109,726	1,945

Table 13--Volume of growing stock and sawtimber on commercial forest land in native and naturalized forests classified as commercial forest types by diameter class and species, island of Hawaii, 1970

Diameter class (inches at breast height)	Species			
	All	'Ōhi'a	Koa	Monkey-pod
Growing stock				
	Thousand feet			
5.0-6.9	5,739	5,699	40	--
7.0-8.9	13,675	13,049	626	--
9.0-10.9	10,986	10,875	75	36
11.0-12.9	9,369	9,326	--	43
13.0-14.9	12,797	11,856	846	95
15.0-16.9	18,693	17,469	1,179	45
17.0-18.9	10,455	10,455	--	--
19.0-28.9	36,003	27,430	8,489	84
29.0-38.9	16,629	7,900	8,729	--
39.0 and larger	6,506	1,272	5,234	--
All classes	140,852	115,331	25,218	303
Sawtimber (International 1/4-inch rule)				
	Thousand board feet			
11.0-12.9	46,204	45,876	--	328
13.0-14.9	73,285	66,990	5,647	648
15.0-16.9	122,802	114,288	8,192	322
17.0-18.9	73,380	73,380	--	--
19.0-28.9	264,710	200,606	63,457	647
29.0-38.9	128,540	60,505	68,035	--
39.0 and larger	51,798	9,864	41,934	--
All classes	760,719	571,509	187,265	1,945

Table 14--Volume of sawtimber on commercial forest land in native and naturalized forests classified as commercial forest types by species and quality classes, island of Hawaii, 1970

Species	Quality class					
	Saw logs all grades	Factory lumber logs			Tie and timber logs	Cull logs ²
		Grade	Grade	Grade	Grade	Grade
		1	2	3	4	5
		Thousand board feet ¹				
'Ōhi'a	571,509	12,200	31,234	265,396	256,016	6,663
Koa	187,265	38,707	36,568	98,481	11,197	2,312
Monkey-pod	1,945	395	--	329	1,221	--
All species	760,719	51,302	67,802	364,206	268,434	8,975

¹International 1/4-inch rule.

²Some individual logs in sawtimber trees that do not meet specifications for factory or tie and timber logs.

Table 15--Number and gross cubic-foot volume of koa and monkey-pod craftwood bolts on commercial forest land in native and naturalized forests classified as commercial forest types by diameter class and species, island of Hawaii, 1970

Diameter (inches)	Both species		Koa		Monkey-pod	
	Number of craftwood bolts	Cubic feet	Number of craftwood bolts	Cubic feet	Number of craftwood bolts	Cubic feet
	<u>Thousands</u>					
9.0-11.9	1,062	2,553	955	2,295	107	258
12.0-16.9	748	3,432	719	3,298	29	134
17.0-21.9	408	3,383	408	3,383	--	--
22.0-25.9	111	1,397	111	1,397	--	--
26.0-29.9	44	759	44	759	--	--
30.0 and larger	10	202	10	202	--	--
All classes	2,383	11,726	2,247	11,334	136	392

Table 16--Number and volume of treeferns on commercial forest land in native and naturalized forests classified as commercial forest types by diameter classes and species, island of Hawaii, 1970

Diameter class (inches)	Species					
	All		Hāpu'u-pulu		Hāpu'u-'i'i	
	Number of trees	Volume (Cubic feet)	Number of trees	Volume (Cubic feet)	Number of trees	Volume (Cubic feet)
	<u>Thousands</u>					
5.0-6.9	183	331	183	331	--	--
7.0-8.9	712	1,921	228	638	484	1,283
9.0-10.9	1,842	6,586	965	3,292	877	3,294
11.0-12.9	1,731	10,096	842	4,792	889	5,304
13.0-14.9	1,010	7,954	521	4,149	489	3,805
15.0-16.9	484	5,708	136	1,279	349	4,429
17.0-18.9	274	3,713	87	1,317	187	2,396
19.0 and larger	520	9,858	99	1,973	421	7,885
All classes	6,756	46,167	3,061	17,771	3,696	28,396

Table 17--Volume of treefern on commercial forest land in native and naturalized forests classified as commercial forest types, by merchantable length class and diameter class, island of Hawaii, 1970

Merchantable length class (feet)	Diameter class (inches) ¹				
	All	5.0- 10.9	11.0- 14.9	15.0- 18.9	19.0 and larger
	Thousand cubic feet				
Less than 4.0	--	--	--	--	--
4.0-6.9	11,282	5,218	5,232	706	126
7.0-8.9	6,345	2,117	1,730	1,513	985
9.0-10.9	11,007	842	5,402	2,513	2,250
11.0-12.9	5,566	--	3,108	922	1,536
13.0-18.9	8,844	661	1,817	2,487	3,879
19.0 and larger	3,123	--	761	1,280	1,082
Total	² 46,167	8,838	18,050	9,421	9,858

¹Diameter at 1 foot above the ground or at the point on the stem where excessive taper ends.

²Sixty-two percent is *Cibotium menziesii*.

Table 18--Net annual growth of growing stock and sawtimber on commercial forest land in native and naturalized forests classified as commercial forest types by species and owner group, island of Hawaii, 1970

Species	All owners	Public	Private
	Growing stock		
	Thousand cubic feet		
'Ōhi'a	1,589.7	841.2	748.5
Koa	¹ -553.0	¹ -206.2	¹ -346.8
All species	1,036.7	635.0	401.7
	Sawtimber (International 1/4-inch rule)		
	Thousand board feet		
'Ōhi'a	6,357.1	2,848.1	3,509.0
Koa	¹ -4,524.0	¹ -1,546.1	¹ -2,977.9
All species	1,833.1	1,302.0	531.1

¹Negative growth is the result of annual mortality exceeding gross growth.

Table 19--Average annual mortality of growing stock and sawtimber on commercial forest land in native and naturalized forests classified as commercial forest types, by species and owner group, island of Hawaii, 1970

Species	All owners	Public	Private
Growing stock			
----- Thousand cubic feet -----			
'Ōhi'a	599.7	367.1	232.6
Koa	892.1	302.5	589.6
All species	1,491.8	669.6	822.2
Sawtimber (International 1/4-inch rule)			
----- Thousand board feet -----			
'Ōhi'a	3,798.5	2,092.5	1,706.0
Koa	6,689.3	2,289.3	4,400.0
All species	10,487.8	4,381.8	6,106.0

Table 20--Area of forest plantations, by island and forest type, Hawaii, 1970

Island	Total all types	Total non- commercial types	Total commercial types	Commercial types				
				Eucalyptus	Other hardwoods	Conifers	Unclassified	
	<div>Acres</div>							
	Hawaii	18,060	2,691	15,369	6,367	6,591	384	2,027
	Kahoolawe	--	--	--	--	--	--	--
	Kauai	5,588	2,164	3,424	1,698	475	1,251	--
	Lanai	1,064	470	594	262	55	80	197
	Maui	10,624	4,561	6,063	3,465	492	2,106	--
	Molokai	2,636	533	2,103	1,267	30	806	--
	Niihau	--	--	--	--	--	--	--
	Oahu	8,188	2,139	6,049	3,615	1,025	195	1,214
	All islands	46,160	12,558	33,062	16,674	8,668	4,822	3,438

Table 21--Volume of growing stock and sawtimber in commercial forest plantations by species and island, Hawaii, 1970

Species	State total	Hawaii	Kahoo- lawe	Kauai	Lanai	Maui	Molokai	Niihau	Oahu
Growing stock									
Thousand cubic feet									
Eucalyptus	56,739	22,524	--	4,852	613	17,412	3,958	--	7,380
Other hardwoods	4,964	2,154	--	1,104	163	429	1	--	1,113
Conifers	7,289	980	--	1,528	100	3,498	758	--	425
All species	68,992	25,658	--	7,484	876	21,339	4,717	--	8,918
Sawtimber (International 1/4-inch rule)									
Thousand board feet									
Eucalyptus	260,069	107,795	--	19,950	2,188	84,572	14,015	--	31,549
Other hardwoods	17,786	6,895	--	5,978	690	1,360	--	--	2,863
Conifers	18,017	2,666	--	2,526	63	10,492	284	--	1,986
All species	295,872	117,356	--	28,454	2,941	96,424	14,299	--	36,398

DEFINITIONS OF TERMS

Land Classes

Land areas are those reported by the Bureau of the Census as land, including dry land, marshes, streams less than 1/8 mile wide, and water bodies less than 40 acres.

Forest reserves are lands set aside through statute or executive order for various conservation purposes. The reserves include privately owned lands as well as state-owned lands.

FOREST LAND

Land at least 16.7 percent stocked by forest trees of any size, or formerly having such tree cover and not currently developed for other use; and land supporting shrubs, the crowns covering more than 50 percent of the ground. The minimum area recognized as forest land is 1 acre.

Commercial Forest Land

Forest land which is producing, or can produce usable crops of industrial wood and is not withdrawn from timber utilization by statute or administrative regulation.

Noncommercial Forest Land

Forest Land not yielding crops of industrial wood.

Productive Reserved Forest Land—Land capable of producing timber crops, but reserved from commercial timber use through administrative regulation or statute, such as national parks.

Unproductive Forest Land—Forest land incapable of yielding usable crops of industrial wood because of adverse site conditions. Includes forest lands which although unproductive for timber, may be productive for range, water, recreation, or wildlife.

NONFOREST LAND

Land that has never supported forests, or was formerly forested and is currently developed for nonforest uses. Includes cultivated areas, pastures, and urban areas.

Ownership Classes

PUBLIC OWNERSHIP GROUP

Hawaiian Homes Lands

State-owned lands administered by the Hawaiian Homes Commission.

Other State Lands

State-owned lands, with the exception of Hawaiian Homes Lands.

Miscellaneous Federal Lands

All federally-owned lands, with the exception of national parks and monuments.

PRIVATE OWNERSHIP GROUP

Corporate Lands

Lands owned by private corporations, companies, or other business groups.

Individual Lands

Lands under individual private ownership.

Forest Types

COMMERCIAL FOREST TYPES

Forests of commercial tree species on commercial forest land or productive reserved land, which are sawtimber stands or are likely to develop into such stands. Commercial tree species occupy at least 10 percent of the growing space occupied by trees.

Commercial Native and Naturalized Forest Types

Forests of native and introduced commercial tree species established through natural processes.

'Ohi'a—Forests in which 'ohi'a trees are predominant and make up 25 percent or more of the stand, and in which koa or other trees make up less than 25 percent of the stand.

Koa—Forests in which koa trees are predominant and make up 25 percent or more of the stand, and in which 'ohi'a or other trees make up less than 25 percent of the stand.

'Ohi'a koa—Forests in which koa and 'ohi'a trees are predominant and each make up 25 percent or more of the stand.

Monkey-pod—Forests in which monkey-pod trees are predominant and make up 25 percent or more of the stand.

Commercial Forest Plantations

Forests of planted commercial tree species with at least 10 percent of the growing space occupied by

planted tree species, regardless of the predominance of native and naturalized species.

Eucalypts—Forest plantations predominantly of commercial *Eucalyptus* species.

Other hardwoods—Forest plantations predominantly of commercial broad-leaved (dicotyledonous) species other than eucalypts.

Conifers—Forest plantations predominantly of commercial softwood species. These are evergreens, usually having needles or scale-like leaves.

NONCOMMERCIAL FOREST TYPES

Forests of noncommercial tree species on commercial forest land, or of any species on noncommercial forest land. These are forests that will not develop sawtimber.

Noncommercial native and Naturalized Forest types

Forests of native and introduced noncommercial species established through natural processes.

Tree Types—Forests in which trees occupy 10 or more percent of the area: *Kukui type*—Forests in which kukui trees are the predominant species; *Kiawe type*—Forests in which kiawe trees are the predominant species; *'Ohi'a-koa type*—Forests in which 'ohi'a or koa trees, singly or in combination, are the predominant tree species, on sites where these species will not likely develop into sawtimber trees; and *Other noncommercial tree types*—Tree types not defined elsewhere.

Shrub Type—Woody vegetation is the predominant cover, with trees occupying less than 10 percent of the area. Includes koa-haole (*Leucaena glauca*), guava (*Psidium* spp.), lantana (*Lantana camara*), pukiaue (*Styphelia tameiameia*), and mamane (*Sophora chrysophylla*).

Noncommercial Forest Plantations

Forests of planted noncommercial tree species, or of planted commercial tree species on noncommercial forest land, with at least 10 percent of the growing space occupied by planted tree species, regardless of the predominance of native and naturalized species.

Tree Classes

GROWING STOCK

Live trees of commercial species that are now or may be expected to become suitable for use as industrial wood.

Sawtimber Trees

Live trees of commercial species at least 11.0 inches diameter breast height (d.b.h.). Conifers must contain at least one 12-foot saw log, and hardwoods one 8-foot saw log.

Poletimber Trees

Live trees of commercial species between 5.0 and 10.9 inches d.b.h., having the soundness and form necessary to develop into sawtimber trees.

Seedling and Sapling Trees

Live trees of commercial species less than 5.0 inches d.b.h., and having the potential to become poletimber trees.

SOUND CULL TREES

Live trees 1 inch d.b.h. or larger which do not qualify as growing stock because of species, poor form, or excessive limbs.

ROTTEN CULL TREES

Live trees 1 inch d.b.h. or larger, which are not growing stock or sound cull because of excessive rot.

SALVABLE DEAD TREES

Standing or down dead trees, of commercial species, 11.0 inches or more d.b.h., containing 50 percent or more of sound volume and at least one merchantable 8-foot log.

Stand-size Classes

SAWTIMBER STANDS

Stands at least 10 percent stocked with growing stock, with one-half or more of the stocking in sawtimber and poletimber trees, and with sawtimber stocking at least equal to poletimber.

POLETIMBER STANDS

Stands failing to qualify as sawtimber but at least 10 percent stocked with growing stock trees, at least half poletimber.

SAPLING AND SEEDLING STANDS

Stands not qualifying as sawtimber or poletimber, but at least 10 percent stocked with seedlings and saplings.

Timber Volume

The International ¼-inch kerf log rule is the standard board-foot log rule adopted nationally by the Forest Service for the presentation of Forest Survey timber volume statistics.

SAWTIMBER VOLUME

The net volume of the saw log portion of sawtimber trees, in board feet, International ¼-inch rule.

SAW LOG PORTION

The bole of sawtimber trees between the stump and the saw log top, 9 inches diameter outside bark (d.o.b.). Logs must meet minimum specifications of approved log grades to qualify as saw logs.

UPPER STEM PORTION

The bole of sawtimber trees above the saw log top to a 4-inch top d.o.b., or to the point where the central stem breaks into limbs.

CRAFTWOOD BOLTS

Those 4-foot sections of the upper stem or limbs of koa and monkey-pod trees, exclusive of the saw log portion, having diameters of 9 inches or greater inside bark at the small end, and meeting minimum defect specifications.

GROWING STOCK VOLUME

Volume in cubic feet of sound wood in the bole of sawtimber and poletimber trees from the stump to a minimum top d.o.b. of 4.0 inches, or to the point where the main stem breaks into limbs.

ALL TIMBER VOLUME

Volume in cubic feet of sound wood in the bole of growing stock, cull, and salvable dead trees 5.0 inches d.b.h. or larger, from the stump to a minimum top d.o.b. of 4.0 inches.

TREEFERN

Gross volume in cubic feet of fern trunks from ground level to a point 3 feet below the base of live fronds.

Tree Species

Commercial tree and treefern species—Tree species suitable for industrial wood products.

Hardwoods

Scientific name	Common name
<i>Acacia koa</i>	Koa
<i>Metrosideros collina</i> (Polymorpha)	'Ohi'a
<i>Pithecellobium saman</i>	Monkey-pod
<i>Eucalyptus</i> spp.	Eucalypts

Other hardwoods—Includes *Albizia* spp., *Fraxinus* spp., *Grevillea* spp., *Flindersia* spp., and others.

Conifers—Includes *Pinus* spp., *Araucaria* spp., *Cryptomeria* spp., *Agathis* spp., and others.

Treefern

Scientific name	Common name
<i>Cibotium splendens</i>	Hapu'u-pulu
<i>Cibotium menziesii</i>	Hapu'u-'i'i

Noncommercial tree species—Tree species not suitable for industrial wood products.

Scientific name	Common name
<i>Aleurites moluccana</i>	Kukui
<i>Prosopis pallida</i>	Kiawe

Other Useful Terms

Diameter breast height(d.b.h.)—Tree diameter in inches, outside bark, measured at 4½ feet above the ground for normal trees, and 18 inches above the stilt or swell for abnormal trees.

Diameter of treefern—Trunk diameter, in inches, measured 1 foot above the ground or just above any excessive basal swell.

Industrial wood—Commercial roundwood products, such as saw logs, veneer logs, and pulpwood; fuelwood, fence posts, and treefern are excluded.

Log grades—A classification of logs based on external characteristics as indicators of quality or value. Grade 1 is the highest quality, grade 2 intermediate, and grade 3 lowest quality of standard hardwood factory logs (USDA Forest Serv. 1965). Grade 4 logs are suitable for ties and timbers.

Mortality—The growing stock or sawtimber wood volume lost because of tree death; often given as average annual mortality.

Net annual growth—The annual change in the volume of growing stock or sawtimber.

Stand basal area—The combined cross-sectional area of trees 5 inches d.b.h. or larger in a stand, usually expressed in square feet per acre.

Stocking classes—A classification of forest stands according to the extent that growing space is occupied by trees, expressed in square feet of basal area per acre.

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The second survey of Hawaii's forest resources, like the first, was a cooperative effort between the State of Hawaii and the U.S. Forest Service. Slightly less than half the State is considered forest land. A significant portion of the land area of each of the five main islands—some 902,000 acres—is classified as commercial forest land. Native and naturalized commercial forest types contain 140.9 million cubic feet of wood. The average sawtimber volume per acre is 3200 board feet. Only 7 percent of the sawtimber volume is in grade 1 factory logs, a proportion indicative of the relatively low quality of native timber. 'Ohi'a sawtimber growth exceeded mortality. Koa sawtimber, on the other hand, showed a negative growth rate.

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Retrieval Terms: Forest surveys; timber inventory; Hawaii.

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